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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/700,236	05/09/2001	Xiong Zhang	83973/269224	3694

7590 03/18/2003

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EXAMINER	
SONG, MATTHEW J	
ART UNIT	PAPER NUMBER
1765	15

DATE MAILED: 03/18/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

Office Action Summary	Application No.	Applicant(s)
	09/700,236	ZHANG ET AL.
	Examiner	**Art Unit**
	Matthew J Song	1765

-- Th MAILING DATE of this communication appears on the cov r sheet with th correspond nce address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 18 November 2002 .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-14 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-14 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claim 12 is rejected under 35 U.S.C. 102(e) as being anticipated by Ishikawa et al (US 5,977,565).

Ishikawa et al discloses a layer **103** grown by MOCVD includes one or more pairs of a thin GaN layer and a thin InGaN and an additional GaN layer. Ishikawa et al also discloses the GaN layers have a thickness of about 1-10nm, typically 4 nm, and the InGaN layers have a thickness of about 1-5 nm, typically 2 nm (col6, ln 35-55). Ishikawa et al also teaches a second cladding layer **104** of p-type $In_xAl_yGa_{(1-x-y)}N$, thereon (col 8, ln 40-65)

Ishikawa et al discloses alternating GaN and InGaN layers but is silent to their lattice constants and energy band gaps. However, GaN and InGaN inherently have different lattice constants and energy band gaps because GaN and InGaN have different compositions.

Ishikawa et al is silent to the deposition temperatures. However, applicant is reminded claim 12 is directed to a product, although claim 12 specifically recites process limitations, the

patentability determination of a product-by-process claim is based on the patentability of the product and does not depend on its method of production (MPEP 2113).

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-6 and 8-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Koide et al (US 6,040,588).

Koide et al discloses a method of making a semiconductor device, where a 3.5 nm thick barrier layer **5a** made of GaN is formed at 900°C, by MOVPE, this reads on applicant's MOCVD, and a 3.5 nm thick quantum well layer **5b** made of $In_{0.16}Ga_{0.84}N$ is formed at 750°C and by repeating this process, five layers of barrier layers and five layers of quantum well layers are obtained, this reads on applicant's periodic or non-periodic buffer. Koide et al also discloses by adjusting the reaction time, the thickness of the barrier layers and quantum well layers are adjusted (col 6, ln 1-67). Koide et al also discloses it is preferred that the thickness of the quantum well layer is 3 to 5 nm and the thickness of the barrier layer is set to 3nm or more (col 5, ln 20-67), overlapping ranges are held to be obvious (MPEP 2144.05). Koide et al also teaches luminous intensity changes with the thickness of the quantum well layer, this is a teaching that thickness is a result effective variable (col 5, ln 1-20). Koide et al also discloses a 30 nm thick

magnesium doped layer **7a** made of p-$Al_{0.15}Ga_{0.85}N$ is formed by keeping the temperature at 1000°C (col 6, ln 60-67). Koide et al also discloses a light emitting layer **5** is formed by laminating a 3.5 nm thick barrier layer **5a** of GaN and a 3.5 nm thick quantum well layer **5b** of $In_{0.16}Ga_{0.84}N$ and the thickness of the quantum well layer is varied to 10 nm, 7nm, 5nm and 3 nm (col 4, ln 25 to col 5, ln 20). Koide et al also discloses a sapphire substrate **1**.

Koide et al teaches the thickness of the quantum well layer is 3 to 5 nm and the thickness of the barrier layer is set to 3nm or more. Koide et al does not teach a thickness in the range from 2 nm to 6 nm. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 1, Koide et al teaches compound semiconductor layers of GaN with a thickness of 3.5 nm and $In_{0.16}Ga_{0.84}N$ with a thickness of 10 nm, 7nm, 5nm and 3 nm, which inherently have different lattice constants and energy band gaps.

Referring to claim 2, Koide et al teaches a p-$Al_{0.15}Ga_{0.85}N$ layer is formed by keeping the temperature at 1000°C.

Referring to claim 3-4, Koide et al teaches MOVPE, this reads on applicant's MOCVD.

Referring to claim 6, Koide et al teaches a sapphire substrate **1**.

Referring to claim 8, Koide et al teaches five, 3.5 nm quantum layers and five, 3.5 nm barrier layers and the total thickness can be determined to be 35 nm. Koide et al does not teach 3 periods or repeating AB units and a total layer thickness is approximately 24 nm. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Koide et al by optimizing the number of period and thickness by conducting routine experimentation.

Referring to claim 10, Koide et al teaches $In_{0.16}Ga_{0.84}N$ and GaN.

Referring to claim 13-14, Koide et al teaches five, 3.5 nm quantum layers and five, 3.5 nm barrier layers and the total thickness can be determined to be 35 nm. Overlapping ranges are held to be obvious (MPEP 2144.05).

5. Claims 1-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Razeghi et al in view of Shakuda (US 5,838,029).

Razeghi et al discloses confinement layer comprising a superlattice structure having from about 5 to about 500 alternating layers of AlGaN and GaN with a total thickness of less than 5000 angstroms on sapphire substrate, this reads on applicant's periodic or non-periodic buffer (col 4, ln 1-67). Razeghi et al also discloses layers of GaN have a thickness of about 10 to about 30 angstroms (1-3 nm) and the layers of AlGaN have a thickness of about 10 to about 100 angstroms (1-10 nm), note claims 6-7. Razeghi et al also discloses a contact layer of GaN doped with silicon magnesium, thereon (col 5, ln 5-67). Razeghi et al also discloses growth of the layers by MOCVD and GaInN may be substituted for AlGaN in the confinement layer (col 4, ln 1-67). Razeghi et al also discloses the growth temperature for AlGaN is 800-1000°C, InGaN is 700-800°C and GaN is 800-1000°C.

Razeghi et al does not disclose the group III-nitride compound is formed at a temperature higher than the first temperature

In a method of forming gallium nitride, note entire reference, Shakuda teaches forming a 0.01 to 0.2 micrometer thick low temperature buffer layer of a gallium nitride type compound semiconductor layer on a substrate at a low temperature of 400-700°C and forming a 2 to 5 micrometer thick gallium nitride type compound semiconductor layer at higher temperature of

700-1200°C, so that the low temperature buffer layer relaxes the lattice mismatch between the substrate and the low temperature buffer layer and prevents crystal defects or dislocations (col 4, ln 1-67 and col 1, ln 30-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Razeghi et al with Shakuda's low temperature buffer layer followed by a high temperature growth to prevent crystal defects in surface layers.

Referring to claim 1, the combination of Razeghi et al and Shakuda teach a thickness of 1-3 nm for GaN and a thickness of 1-10 nm. The combination of Razeghi et al and Shakuda does not teach the claimed range of 2-6 nm. Overlapping ranges are held to be obvious (MPEP 2144.05). Also GaN and AlGaN inherently have different energy gaps and lattice constants because GaN and AlGaN have different compositions.

Referring to claim 2, Razeghi et al GaN doped with silicon magnesium, this reads on applicant's p-type group III nitride compound semiconductor because magnesium is a well known p dopant for GaN.

Referring to claim 3-4, Razeghi et al teaches a superlattice of 10 angstroms of GaN and 100 angstrom of AlGaN.

Referring to claim 5, the combination of Razeghi et al and Shakuda teach AlGaN and InGaN can be substituted.

Referring to claim 7, the combination of Razeghi et al and Shakuda teach a first growth temperature of 400-700°C and a second growth temperature of 700-1200°C. Temperature is well known in the art to be a result effective variable. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Razeghi et al

and Shakuda by optimizing the temperature by conducting routine experimentation of a result effective variable (MPEP 2144.05).

Referring to claim 8, the combination of Razeghi et al and Shakuda does not teach 3 periods or repeating AB units and a total layer thickness is approximately 24 nm. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Razeghi et al and Shakuda by optimizing the number of period and thickness by conducting routine experimentation.

Referring to claim 9-10, the combination of Razeghi et al and Shakuda teach AlGaN can be substituted with InGaN.

Referring to claims 13-14, the combination of Razeghi et al and Shakuda teach a total thickness of less than 5000 angstroms (500 nm). Overlapping ranges are held to be obvious (MPEP 2144.05).

6. Claims 1-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Schetzina (US 5,670,798) in view of Shakuda (US 5,838,029).

Schetzina discloses a multiple quantum well including alternating layers of aluminum nitride or aluminum gallium nitride and gallium nitride and the thickness of the layers of gallium nitride increase from adjacent a first layer to opposite the first layer (col 7, ln 1-67). Schetzina also discloses group III-V nitride materials are deposited by MOCVD (col 10, ln 1-40) on a sapphire substrate **132**, note Fig 5. Schetzina also discloses a sequence of GaN quantum wells having a thickness of 10, 7, 5, 4, 3, 2 and 1 monolayers (5, 3.5, 2, 1.5, 1, and 0.5 nm, respectively), where a monolayer is 5 angstroms, separated by about 15-25 angstrom (1.5-2.5

nm) AlN barriers (col 13, ln 1-67). Schetzina also discloses a multiple quantum well of alternating layers of AlGaN and GaN and the thickness of the GaN increases from adjecant AlGaN and the thickness of AlGaN remains constant (col 12, ln 1-67). Schetzina also teaches p-GaN layer **124a** on the multiple quantum well (Fig 5).

Schetzina does not disclose the group III-nitride compound is formed at a temperature higher than the first temperature

In a method of forming gallium nitride, note entire reference, Shakuda teaches forming a 0.01 to 0.2 micrometer thick low temperature buffer layer of a gallium nitride type compound semiconductor layer on a substrate at a low temperature of 400-700°C and forming a 2 to 5 micrometer thick gallium nitride type compound semiconductor layer at higher temperature of 700-1200°C, so that the low temperature buffer layer relaxes the lattice mismatch between the substrate and the low temperature buffer layer and prevents crystal defects or dislocations (col 4, ln 1-67 and col 1, ln 30-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Schetzina with Shakuda's low temperature buffer layer followed by a high temperature growth to prevent crystal defects in surface layers.

Referring to claim 1, the combination of Schetzina and Shakuda teaches a GaN quantum wells having a thickness 5, 3.5, 2, 1.5, 1, and 0.5 nm separated by about 1.5-2.5 nm AlN barriers. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 7, the combination of Schetzina and Shakuda teach a first growth temperature of 400-700°C and a second growth temperature of 700-1200°C. Temperature is well known in the art to be a result effective variable. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Razeghi et al

and Shakuda by optimizing the temperature by conducting routine experimentation of a result effective variable (MPEP 2144.05).

Referring to claim 8, the combination of Schetzina and Shakuda does not teach 3 periods or repeating AB units and a total layer thickness is approximately 24 nm. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Schetzina and Shakuda by optimizing the number of period and thickness by conducting routine experimentation.

Referring to claim 13-14, the combination of Schetzina and Shakuda teaches a GaN quantum wells having a thickness 5, 3.5, 2, 1.5, 1, and 0.5 nm separated by about 15-25 angstrom (1.5-2.5 nm) AlN barriers. The total thickness can be determined by summing the thickness to obtain a total thickness of 25.5 nm for an AlN thickness of 2 nm. Overlapping ranges are held to be obvious (MPEP 2144.05).

Response to Arguments

7. Applicant's arguments with respect to claims 1-14 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Chen et al (US 6,495,867) teaches a multi-layer buffer layer comprising InGaN, AlGaN and GaN (claim 1).

Shmagin et al (US 5,875,052) teaches MOCVD of a quantum well of 3 nm thick InGaN layers and 5 nm thickn GaN layers with a capping layer of AlGaN (col 5).

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 703-305-4953. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Benjamin L Utech can be reached on 703-308-3868. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

Matthew J Song
Examiner
Art Unit 1765

MJS
March 14, 2003

BENJAMIN L. UTECH
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